Application of a Subgrid Orography Scheme to a Global Climate Model

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Assessments of the impacts of climate change typically require information at scales of 10 km or less. Such a resolution will not be achieved by global climate models for many years. We have developed an alternative to explicit resolution that can meet the needs of climate change impact assessment now. We have applied to a global climate model a physically-based subgrid-scale treatment of the influence of orography on temperature, clouds, precipitation, and land surface hydrology.

The treatment represents subgrid variations in surface elevation in terms of fractional area distributions of discrete elevation classes. For each class it calculates the height rise/descent of air parcels traveling through the grid cell, and applies the influence of the rise/descent to the temperature and humidity profiles of the elevation class. Cloud, radiative, and surface processes are calculated separately for each elevation class using the same physical parameterizations used by the model without the subgrid parameterization. The simulated climate fields for each elevation class can then be distributed in post-processing according to the spatial distribution of surface elevation within each grid cell.

Parallel 10-year simulations with and without the subgrid treatment have been performed. The simulated temperature, precipitation and snow water are mapped to 2.5 minute (~ 5 km) resolution and compared with gridded analyses of station measurements. The simulation with the subgrid scheme produces a much more realistic distribution of snow water and significantly more realistic distributions of temperature and precipitation than the simulation without the subgrid scheme. Moreover, the grid cell means of most other fields are virtually unchanged by the subgrid scheme. This suggests that the tuning of the climate model without the subgrid scheme is also applicable to the model with the scheme.